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July 10, 2014
REPA5-2205-036

Ms. Patricia Rosa
Contracting Officer
U.S. EPA Region 2
290 Broadway
22nd Floor
New York, NY 10007-1966

Re: <u>Contract No. EP-BPA-12-W-0005</u>
<u>RCRA Enforcement, Permitting, and Assistance Contract, REPA5, Region 2</u>

Subject: <u>Task Order No. 005, Technical Evaluation of Petroleum Hydrocarbon Contamination in Guayanilla Bay, Puerto Rico</u>

Dear Ms. Rosa:

In response to Task Order No. 005, under Contract No. EP-BPA-12-W-0005, Booz Allen Hamilton (Booz Allen) has prepared the following technical evaluation of petroleum hydrocarbon contamination at the Commonwealth Oil Refining Company (CORCO) and Shell Oil Terminal as possible sources of a continuing release of oil observed in Guayanilla Bay, Puerto Rico. Note that the figures to the report are being submitted as separate files due to their large size.

If you have any questions on this deliverable, please contact me at (919) 462-9004.

Sincerely,

Connie Crossley

BOOZ ALLEN HAMILTON, INC.
Connie Crossley
Task Order Manager

cc: Luis Negron, EPA TOCOR
Louise Easton, CO
Eduardo Gonzalez, EPA
David Cuevas, EPA

TECHNICAL EVALUATION

PETROLEUM HYDROCARBON CONTAMINATION

GUAYANILLA BAY, PUERTO RICO

July 10, 2014
Repa5-2205-036

1.0 INTRODUCTION

The following is a technical evaluation to determine the possible causes of a continuing release of oil observed in Guayanilla Bay, Puerto Rico. Oil sheens have been observed during periods of heavy rain over a period of 9 years. The discharge has been associated with a storm drain outflow into Guayanilla Bay, Puerto Rico. This discharge was initially investigated by the U.S. Coast Guard (USCG). In March 2013, the USCG was able to identify a storm drain basin with pooled oil near the discharge point in Guayanilla Bay, Puerto Rico. Initially, a response action was undertaken to recover oil from the storm drain in an effort prevent further discharge. However, the flow of product proved to be continuous, suggesting a significant upgradient source. Initial investigations identified three potential Responsible Parties: Puerto Rico Electric Power Authority (PREPA) Costa Sur, Commonwealth Oil Refining Company (CORCO), and an adjacent site owned by Shell Energy North America (Shell). The locations of the storm drain outflow and basin (grate) relative to Guayanilla Bay, as well as the PREPA Costa Sur, CORCO, and Shell properties are shown on Figure 1 (USCG, 2013b; Slide 7)(USCG, 2013a).

Further investigations were undertaken to sample the area utilizing Geoprobe techniques to identify the source and path of discharge. This Geoprobe investigation traced the presence of contamination back to the Shell and CORCO property back along State Road PR-127 (PR-127). Samples were subsequently taken from monitoring wells located around each facility. These samples showed a similar concentration and appearance to the oil samples taken from the storm drain basin and outflow. Samples of products from these locations were subsequently sent off for fingerprint analysis. The fingerprinting analyses suggested strong similarities between the product identified in the storm drain and the samples taken from the Shell and CORCO wells (USCG, 2013).

The presence of significant plumes of petroleum products floating on the water table as light nonaqueous phase liquids (LNAPL) at both the Shell and CORCO facilities has been known for years. Due to the close proximity of the Shell property to the storm drain, the Shell plume would appear to be the most probable source of the product discharging to Guayanilla Bay via the storm drain. However, the source of the phase separated hydrocarbon (PSH) plume on the Shell

property has long been contested, with Shell contending that the product found beneath its property is the result of releases at the CORCO facility. As a result, it is unclear whether the product observed in the storm drain discharging to Guayanilla Bay results from a release at CORCO or Shell.
The documentation for both the Shell and CORCO sites as well as the results of the fingerprinting analysis were reviewed in an effort to determine the source of the product discharging to Guayanilla Bay. The documents used in this reviewed are identified in the list of references provided at the end of this report. Due to the importance of the Shell and CORCO PSH plumes, much of the review and analysis of presented in this report focuses on the historical data available on the petroleum releases at the site and to evaluate the potential migration of these releases in the study area.

A brief discussion of the background for the study area is presented in Section 2 of this report. An evaluation of the source of the PSH discharging to Guayanilla Bay is presented in Section 3.0. This evaluation includes an historical evaluation of the PSH plume on the Shell and CORCO properties and an evaluation the soil sampling and screening investigations conducted at the Shell site to identify evidence of a significant release at the Shell site. The source evaluation concludes with a discussion of the hydrocarbon fingerprint analysis conducted at the site. Section 4.0 of this report presents the conclusions based on the source evaluation and Section 5.0 presents recommendations for further investigation and analysis.

2.0 BACKGROUND

The study area is located in the Penuelas-Guayanilla Industrial Area in the municipalities of Penuelas and Guayanilla. The area is heavily industrialized and includes the former Shell terminal, the CORCO facility, PREPA Costa Sur power generation facility, and a Union Carbide Facility (see Figure 1). The Rio Tallaboa passes to the southeast of the study area and discharges into nearby Tallaboa Bay. The study area is characterized by significant topographical relief, with steeply sloping upland areas grading into relatively flat areas near Rio Tallaboa and the Caribbean Sea.

The study area is located in the Tallaboa-Guayanilla-Guanica subarea of the south coast region of Puerto Rico. The area is underlain is Quaternary alluvium by the Ponce Limestone. Thick deposits of unconsolidated Quaternary alluvial materials consisting of boulders, gravel, sands, silts and clays underlie large portions of the Talloboa Valley. The upland areas are underlain by Ponce Limestone with a thin veneer of soils. The Ponce Limestone is generally massive but includes some thin dense strata and clay facies. Cross-sections depicting the geology across the Shell and CORCO properties are presented in the Guayanilla Site Investigation Summary (URS, 2014; Figures 7 through 11).

The principle water bearing units underlying the study area are the Alluvial Deposits and the Ponce Limestone. While water table elevations vary with precipitation rates, the water table slopes to the southwest. Steeper gradients are observed in upland areas of the CORCO facility but flatten downgradient beneath the former Shell facility. The water table across the Shell facility in 1993 is depicted in Figure 2 (URS, 2014; Figure 3). A generalized water table based on 2011 water-level data is depicted across both the CORCO and Shell sites in Figure 3 (URS, 2014; Figure 4). Based on the available monitoring data, the PSH is present across the study area predominately in the Ponce Limestone

2.1 CORCO

The CORCO facility operated as a petroleum refinery from approximately 1955 to 1982. In the 1980's the facility was converted to a petroleum products terminal and storage business using the deep water dock and storage tanks located on the facility. Refinery operations were terminated 1981. The former refinery units have been dormant since 1982 and are intended for eventual demolition (Newfields, 2013).

CORCO continues to operate as a terminal storage facility for petroleum products. Specifically, it operates tanks to store products for other entities, pending transfer to other locations. Current operations include marine loading docks, a tank farm, and tank truck loading facilities. Products are brought into CORCO through the deep water docks, pumped into tanks for storage, and subsequently are shipped out through either the deep water docks or the truck loading rack to local Puerto Rico retailers.

Prior to termination of the refinery activities, CORCO manufactured several petroleum products. Historically, the facility tanks have been used to store a number of products including crude oil, intermediate and finished petroleum products such as gasoline, diesel, No. 6 fuel oil, kerosene, naphthalene, aviation fuel and sulfuric acid. Currently, the tank farm is used for storage of petroleum products including unleaded gasoline, diesel, No. 6 fuel oil, waste oil and fuel additives.

Petroleum products were accidentally released to the environment at CORCO during historical petroleum refining, storage, transfer activities. Free product was first identified in the subsurface during the Environmental Impact Study Investigation for the Modular Incineration System (MID) Area conducted by Roy F. Weston in 1989 (Newfields, 2004). Since that time, a number of investigations have been conducted to delineate the free product plume at the CORCO site (Newfields, 2004, page 1). A Phase I Subsurface Oil investigation was conducted in 1994 (DSM, 1994). The Phase I Investigation included the installation of 32 wells (PD-1 through PD-32) at various locations throughout the facility. A Phase II subsurface Oil Investigation was conducted in 1995, which included the installation of seven additional delineation wells (DW-1 through DW-7) and five pump test wells (PT-1 through PT-5). The results were compiled in the Phase II Subsurface Product Delineation Report (DSM, 1996). Since the Phase II report, additional wells have been installed during various investigations and have been incorporated into the overall free product monitoring program. These wells include EPRB-1 through EPRB-6 installed in 1996, PDW-1 through PDW-8 and SWP-1 install in 1997: and CA-1 through CA-15 installed in 1998. Figure 3 shows the location of all current monitoring wells in the main CORCO facility as well as adjacent areas.

A description of free product recovery operations at the CORCO facility through 2004 is provided in the Historical Free Production Report (Newfields, 2004). Free product recovery operations began in the MID Area on November 8, 1994 and have continued to the present day at various locations throughout the CORCO facility. From October 1999 through September 2002, ten existing monitoring well have been converted to the pumping wells that comprised the free product recovery system in in 2004. Since the latter part of 2003, free product recovery at CORCO has been enhanced by utilizing a mobile vacuum truck to suction free product from select wells south of route 127.

An evaluation of the thickness of the free product plume from 1994 to 2004 is presented in the Historical Free Production Report (Newfields, 2004). Both graphical and tabular presentations of all the free product measurements during this period are presented in this report. As these data indicated, monitoring the thickness of PSH plume was sporadic prior to 2000. However, since February 2000, all monitoring wells at CORCO have been gauged monthly to monitor the effectiveness of the free product recovery system. As these data indicate, free phase petroleum has been and continues to be present on the groundwater beneath the main area of the site including the product storage tank farm and former refinery units. However, the data also demonstrates that the recovery system has been effective in reducing the LNAPL thickness in many areas of the facility. As of December 2012, recovery operations had removed in excess of seven million gallons of free product (NewFields, 2013)

2.2 The Shell Fuel Terminal

The Shell Fuel Terminal began operations in 1960, ceased operations in 1982, and is currently inactive. The operations of the Shell Fuel Terminal involved only the storage and distribution of hydrocarbon-related products such as gas oil, fuel oil, kerosene, leaded and unleaded gasoline, asphalt, and special fuel oils (DSM, 1998). The tanks, associated piping and ancillary equipment were reported emptied when operations ceased in 1982. However, it appears that some limited residual product was left in each tank after closure of the terminal (DSM, 1998, pp. 4-5). In 1992, the major structures remaining on the site were reported to be two large underground steel tanks (Tanks 1 and 2), and seven above ground tanks, a truck filing rack location, and primarily above ground pipe rack connecting to the truck filling station. The main buildings consisted of a one story main office building and a warehouse (Soil Tech, 1992).

However, a more recent description of the site (URS, 2014) indicates that the former terminal storage and distribution structures within the site included 23 above ground fuel storage tanks and two field constructed fuel storage tanks of varying sizes with associated piping and a truck loading rack station. The two large in-ground tanks (Tanks 1 and 2) were constructed by the

U.S. Navy sometime before 1955 and were made of concrete and steel shaped like a flat vertical cylinder with capacities of approximately 1,674,000 and 1,679,000 gallons. Demolition of all site tanks and structures took place from November 2012 to June 2013, and the site was re-graded to facilitate natural drainage.

The PSH plume beneath the Shell property was first detected in January 1992 during the initial phase of an Environmental Property Assessment conducted from 1991 to 1993 (Soil Tech, 1992). The monitoring network initially installed in 1992 has progressively been expanded to evaluate the PSH plume beneath the site and is now comprised of 18 wells. The locations of these wells are shown on Figure 3, and construction details for all these wells are provided in Table 1 of the Guayanilla Site Investigation Summary (URS, 2014).

Eight monitoring wells (MW-1 through MW-8) were first installed between December 1991 and January 1992 during the initial phase of the Environmental Property Assessment. In addition to these wells, four boreholes were completed to a depth of approximately 10 feet to evaluate potential soil contamination. PSH was detected in all of these wells (except MW-8), with the thickness of PSH ranging from 3 to 8 feet (Soil Tech, 1992). Soil Tech subsequently installed three additional monitoring wells (MW-101 through MW-103) in March 1993 and two additional wells (MW-201 and MW-202) in October 2003 (ERM, 2003). In January 2003, three additional wells (MW301, MW-303, and MW-304) were installed along the border between CORCO and Shell as part of an additional site investigation (ERM, 2003). During this investigation, two additional wells (MW-104 and MW-101A) were discovered on site. These wells were believed to be wells that were installed along the southern border of the Shell site as part of a PSH extraction system that was never operated.

The groundwater and PSH levels have been measured in the monitoring network installed at the Shell site during a series of 8 synoptic monitoring events. These events include twice in January 1992, March and August 1993, August 1995, January and March 2003, and August 2012. The water level and PSH measurements, including PSH thickness and corrected water level measurements, are provided in Table 1 of the Guayanilla Site Investigation Summary (URS, 2014). These data indicate that with the exception of MW-8 and MW-103, PSH has been detected beneath the site. PSH thicknesses have generally been consistent in each monitoring well between monitoring events but have been observed to be gradually decreasing with time. During the initial phase of the Environmental Property Assessment, continuous cores collected during completion of the 4 borings and 9 of 10 monitoring wells (MW-1 through MW-6, MW-101 through MW-103). These boring and monitoring wells were located in areas adjacent to site tanks and other potential areas of release. With the purpose of identifying potential releases, these cores were screened for organic vapors using a Photoionization Detector (PID). The results of this soil screening are available in Tables 2 and 3 of the Property Assessment Report (Soil Tech, 1992).

After demolition of the tanks and structures on the Shell site, a program of surface soil sampling (0 – 1 foot) was conducted between January and June 2013. In addition, due to high PID readings that were observed during the excavation of Tank 1, seven borings were advanced surrounding Tank 1 in May and June 2013 to vertically and horizontally characterize soils around Tank 1. These cores were screened with a PID, and two soil samples were collected from each boring above the LNAPL interface for laboratory analysis. Seven borings were similarly completed in the vicinity of the Truck Loading Rack Station (TFRS) to evaluate potential releases in this area. The results of this additional sampling are reported in the Guayanilla Site Investigation Summary (URS, 2014).

During the 2003 Site Assessment (ERM, 2003), product samples from 15 on-site wells were collected and submitted for Gas Chromatography Fingerprint analysis using EPA Method SW 8015B and for Total Lead Analysis using EPA Method SW 6010B.

3.0 SOURCE EVALUATION

The source of the PSH discharging to Guayanilla Bay and found along the storm drain and nearby areas along Rt. 127 and the southern boundary of the former Shell facility were evaluated using several different approaches. An historical evaluation of the PSH plumes on the Shell and the upgradient CORCO site was used to help identify the source of PSH beneath the Shell site, including the southern portion of that site along Rt. 127. Similarly, the results of soil sampling and analysis as well as soil core screening from the Shell site were used to determine if significant historical releases are evident on Shell facility. Fingerprint analysis of product samples was also useful in determining the source of the product found along the southern boundary of the Shell site, in the storm drain, and discharging to Guayanilla Bay.

3.1 Historical Analysis PSH Plumes

Historical analysis of the PSH plumes on the Shell and GORCO sites provides significant insight into the potential source of PSH on the Shell site, including along the southern boundary adjacent to Rt. 127. Such an analysis is particularly useful because the Shell site terminated operations in 1982. At that time, product was removed from tanks and related structures. While there are some reports of product remaining in the tanks after 1982, these amounts are limited and could not be responsible for the large plume found beneath the Shell site in 1992. As a result, if Shell is responsible for the PSH found beneath its site, the release would have had to occur prior to 1982.

To understand to potential sources of the PSH found throughout the Shell and CORCO site, it is important to understand the behavior of a large PSH release and the resulting plume in the subsurface. As the product is released at or near the ground surface at the source area, it migrates vertically downward. Although the product may be diverted laterally by lower permeability layers in the subsurface, much of the product eventually reaches the water table where it collects and floats on the water table. As it collects on the water table, the product depresses the water table and forms a "lens" of PSH (LNAPL).

As the release continues, the thickness of the LNAPL increases, and the LNAPL begins to spread radially in all directions. Since it is present as a separate phase, the product flows in response to the hydraulic gradients within the hydrocarbon phase itself and not necessarily in response the slope of the water table. Thus, the slope of the water table has minimal influence in the movement of PSH, particularly where the slope of the water table is moderate and/or when the PSH layer is thick. As the release continues, the PSH layer thickens and provides the internal gradients necessary for the PSH to spread laterally. The product tends to spread in all directions, including upgradient along the water table. In the case of a finite release, the PSH collects in a thick lens beneath the release point. However, after the release ends and additional PSH is no longer accumulating on the water table, the LNAPL lens will tend to spread and thin. The PSH lens will continue to spread and thin until it reaches a stable configuration in which the internal gradients are insufficient to overcome the reduced transmissivity at the edges of the lens. Although a plume may be stable, measurements of the thickness of PSH at any location in the plume may be subject to considerable variability overtime. The factor that introduces the greatest variability in the plume is fluctuations in the elevation of the water table. As the water table moves vertically up and down, the thickness of the smear zone changes, which alters the amount of PSH held as residual in the soil and the amount free to flow into a well. Thus, the LNAPL thicknesses observed in a monitoring well generally increases as the water-table elevation decreases and decrease when the water-table elevation increase, although the amount of PSH present at that location has not actually changed. As a result, fluctuations in measured PSH thickness must be evaluated in the context of water level changes.

The amount of PSH observed in a well is also influenced by the physical properties of the subsurface materials. Differences in properties such as porosity, pore size distribution, and entry pressures can result in differing amounts of PSH accumulating in a well although the actual thickness of LNAPL present in the subsurface material is similar. Thus, the uncertainty inherent in using measured thicknesses of LNAPL in a monitoring well to evaluate LNAPL thickness in the subsurface should be recognized.

It is also important to realize that although a PSH plume may be stable in size and no longer spreading, the PSH in the plume is still considered potentially mobile. Thus, recovery tests that indicate that mobile PSH is present internal to a plume do not necessary indicate that the plume, as a whole, is mobile and continues to spread or migrate in the subsurface. It is frequently possible to recover large amounts of a PSH plume that is in an otherwise stable configuration.

Any potential releases that may have occurred at the Shell facility would have ceased by 1982 due to closure of the facility. Consequently, any plume detected beneath the site in 1992 resulting from an on-site release should be stable. The data should indicate a lens-like configuration in which areas of increased thicknesses in the PSH are observed beneath likely release points.

Examination of the measured PHS thicknesses during the initial 1992 to 1993 monitoring period indicates that PSH was initially found to be widely distributed throughout the site, with PSH thickness generally ranging between 5 and 9 feet. Notable areas of increased PSH thickness were beneath the areas surrounding Tank 1(MW-2, MW-3, and MW-7) and Tank 2 (MW-4, MW-5). Ignoring the apparently anomalous PSH measurements during January 1992, which are likely the result of unusually low water table elevations, the PSH thicknesses observed in the Tank 1 area were approximately 6 to 7 feet and the PSH thickness observed in the Tank 2 were 7 to 8.5 feet. These increased thicknesses in observed PSH suggest potential releases in the Tank 1 and Tank 2 areas.

The PSH plume was found to extend north to MW-8, where PSH thicknesses of approximately 6.5 feet were observed. Such PSH thicknesses are consistent with a pattern of radial spreading of PSH from a release area. However, the thickness of the PSH at this location compared to that observed in the potential source area surrounding Tanks 1 and 2 appears large relative to that expected at the thinning edge of a PSH plume.

It is important to note that the greatest thicknesses of PSH initially observed beneath the Shell site were at MW-102, where PSH thicknesses of nearly 9 feet were observed. MW-102 is located in the southeast corner of the facility in an area of no potential release although it is adjacent to the boundary with CORCO.

While the PSH data available from monitoring wells installed on the Shell property may suggest a local release, there were no PSH data available between Tank 2 and the property boundary with CORCO in 1992. However, PSH measurements are available from a series of monitoring wells installed in 1994 by CORCO on its property along the border with Shell. These monitoring wells include PD-30 and PD-31 along the northern border of Shell and PD-23 and PD-09 along the eastern border with Shell (see Figure 3). Measurements in 1994 indicate that no PSH was found along the northern border with Shell in PD-30 and PD-31. However, in September 1994 measurements in PD-23 indicated a thickness of 9.35 feet in PD-23 and 9.71 feet in PD-09. Thus, these measurements indicate a PSH plume of greater thickness than the PSH observed in the Tank 2 area and similar thickness of PSH in MW-102 on the Shell property to that observed at the boundary in nearby PD-09. Moreover, measurements of PSH in DW-3, located in the area immediately northeast of the boundary between Shell and CORCO, indicated a PSH thickness of 9.64 feet. The distribution of LNAPL on the CORCO property in 1994 is depicted in Figure 4 (NewFields, 2004; Figure 3). The Tanks (West Tk 965 and Tk 1011 north) are located adjacent to Shell's eastern boundary and are, at least in part, the likely source of PSH present at the border. Pumping wells PW05 and PW12 have been operated since 2000 by CORCO in an effort to control the plume in this border area.

The increasing thickness of PSH observed to the east of the Shell's Tank 2 immediately across the border at PD-23 and nearby CORCO areas strongly suggest that the plume identified in the area of Shell's Tank 2 is centered on the CORCO property. Similarly, the extension of the PSH plume south along Shell's property boundary to PD-09 strongly suggest that the PSH plume at MW-102 is the result of releases on the CORCO property.

Monitoring well MW-303 and MW-304 were subsequently installed by Shell in 2003 along its eastern border with CORCO to confirm the continuity of the PSH plume across the facility boundary. While the PSH levels were significantly lower at the property border (as well as throughout the Shell property) than observed in PD-23 in 1994 due to PSH recovery operations conducted by CORCO, PSH thicknesses at MW-303 and nearby PD-23 were nearly identical in February and March, 2003 (5.13 ft. at MW-303 versus 5.33 ft. at PD-23). These data confirm the hydraulic continuity of the Shell and CORCO plume.

The hydraulic continuity of the Shell and CORCO plumes is further verified by the decreasing thicknesses of PSH observed throughout the Shell property beginning in 2000 when the CORCO recovery operations were expanded into the area adjacent to the Shell property. For example, the thicknesses of PSH measured in MW-5 ranged from between 8.15 to 8.40 feet between January 1992 and August 1995. After 1995, the thicknesses in MW-5 began to steadily decrease until August, 2012 when a PSH thickness of only 0.02 ft. was measured in MW-5. While some of the recent PSH measurements in MW-5 may be influenced by fluctuations in the water-table elevation, the trend of decreasing PSH thickness at MW-5 in response to the expansion of CORCO recovery operations is unmistakable. The impact of CORCO recovery operations are also particularly noticeable at MW-101 where the PSH thickness of nearly 9 feet in 1995 decreased to 4 feet in 2012. Such reductions in PSH volume on the Shell property in response to recovery operations on the GORCO property are only possible if there is a continuous layer of PSH across the two properties. If the two plumes were hydraulically separated, no reductions in PSH volumes could have occurred in the Shell plume in response to CORCO PSH recovery operations.

3.2 Evaluation of Soil Analysis and Screening Results

During the initial phase of Soil Tech Investigation (December 1992 through January 1993) four soil borings were completed to a depth of 10 feet (see Figure 5 (Soil Tech, 1992; Figure 3). The continuous cores collected in these borings were screened for organic vapors using a Photoionization Detector (PID). The screening only identified significant levels of organic vapor in the top 8 feet of boring B-4, which is located adjacent to Tank No. 4 (Soil Tech, 1993, Table 1). These data suggest a possible release in the vicinity of Tank 4. Soil screening data are also available for the continuous cores taken during the installation of monitoring wells MW-1 through MW-6 (Soil Tech, 1993, Table 2). The screening data from MW-3 indicated significant levels of soil vapor beginning at 14 bgs and extending to the PSH smear zone at the water table. Monitoring well MW-3 is located adjacent to Tank 1 which is constructed below ground. While significant levels of vapor were not detected in shallow soil, the soil vapor detected with depth could be indicative of a release from Tank 1. While the PSH plume may influence soil vapor readings in deeper soil, the distribution of soil vapor detected in MW-3 does not appear attributable only to the influence of the PSH plume. Similar levels of soil vapor were also detected in MW-4 which is adjacent to Tank 2. However, these elevated levels of soil vapor were not encountered until a depth of 34 feet and may be more readily attributable to the PSH plume. However, given the depth of the Tank 2, the possibility of a release from Tank 2 cannot be completely discounted.

Surface soil sampling was also conducted at the Shell facility after demolition and removal of the tanks and terminal structures (URS, 2014). Samples were taken around and beneath all major structures including the tanks. The surface soil samples were taken from 0-1 feet and analyzed for benzene, toluene, ethyl benzene, total xylenes (BTEX) and TPH (GRO, DRO, and ORO). The surface sampling confirmed that the analytes were below their respective Puerto Rico Environmental Quality Board (EQB) Tier 1 action levels, with the exception of TPH. Additional sampling was undertaken to delineate areas with elevated TPH concentrations. These additional samples were compared to EQB Tier 2 action levels, and only one sample from the TFRS exceeded the Tier 2 action level for DRO.

The results of the surface soil sample provide limited evidence of a release. Analytical results from many areas indicated only trace contamination. Other samples near Tank 1, Tank 7, Tank 23, Tank 24, and Tank 25 indicate contaminant levels exceeding Tier 1 levels, but follow-up sampling generally indicated levels of contamination that were not indicative of a significant release. While the surface sampling provides evidence of only limited releases, these data not determinative because of their shallow depth. However, the samples taken from beneath the tanks after their removal provide valuable data regarding any potential releases from the tank. High PID readings were observed during the excavation of Tank 1. As a result, a series of 7 borings were completed in the Tank 1 area. These borings were continuously cored, and the cores screened using a PID. The soil screening only identified elevated soil vapor at or near the smear zone of the PSH plume underlying the Shell site. These soil screening results provided little evidence of a significant release from Tank 1. However, it should be noted that based on cross-sections depicting the boring data (URS, 2014; Figure 14) the bottom of the pit excavated for Tank 1 extended to within 10 feet of the smear zone of the PSH plume underlying the Shell site. Such conditions make difficult the detection of any product releases from the lower portions or bottom of Tank 1.

3.3 Hydrocarbon Fingerprint Analysis

Fingerprint analysis of PSH samples have been undertaken by CORCO, Shell, and the USEPA/Coast Guard.

CORCO Product Characterization

During the 1994 Phase I investigation, CORCO analyzed several samples of free product from wells across the site. The 1994 analysis of free product showed mixtures of crude petroleum fractions from light gas fractions to heavier lubricating oils depending on location. However, the majority of the free product was a blend of diesel and gasoline.

Shell Product Fingerprinting

In 2003, Shell's product fingerprinting studies concluded that a single plume of product (leaded gasoline) is present under the entire site, including the area up-gradient of the storage tanks. Comparison of chromatograms of gasoline, diesel, and kerosene standards with chromatograms of the product samples indicate that the product in all of the wells, including the four up-gradient wells (MW-201, MW-8, MW-303 and MW-304), is predominantly gasoline. Quantification of the gasoline range TPH indicates that the product samples contain between 44 and 96 percent gasoline. The laboratory indicated that this range of results is expected with the large dilution factors required for quantification. The lead analyses indicate that all product samples contain lead at similar concentrations (between 100 and 600 mg/kg).

USEPA/Coast Guard Fingerprinting in 2013

In response to the release of product in the Guayanilla Bay, the US Coast Guard analyzed product samples from monitoring wells, soil borings, manholes and discharge points to the Guayanilla Bay in 2013 (USCG, 2013a). The analysis included product and soil samples taken from a series of Geoprobe locations along Rt. 127 adjacent to the southwest corner of Shell property. The analysis also included samples of free product from three CORCO monitoring wells (PD-09, PD-23, and PW-012) and three Shell monitoring wells (MW-101, MW-102, MW-303). Figure 6 shows the sample locations from monitoring wells (blue) and soil borings (red). Figure 3 can be used as reference for location of the monitoring wells with respect to the property boundaries,

The product fingerprints were compared with gasoline and kerosene standards. All product samples were found to be different mixtures of the same petroleum products. The highest amount of compounds detected were gasoline, kerosene, and mixture of waxy distillate of refined oil. All contained similar ratio of BTEX to alkyl-benzene that is comparable to gasoline. Only the fingerprint of MW-101 showed a pattern did not match the gasoline standard. The report concludes that the difference between the fingerprint of MW-101 and the other samples and the standard gasoline is likely caused by the presence of a "fresh" lighter product such as kerosene. The fingerprint analysis of the samples from CORCO wells PD-09, PD-23, and PW-012 and Shell wells MW-102, MW-303 indicate that the product samples from PD-09 and PW-012 are matches to the product sample from MW-102 and that product samples from PD-23 and MW-303 are a match. The fingerprint analysis further indicates that product in the southwest corner of the Shell property at MW-101 is a mixture of these two product groupings. These data support the previous conclusions based on the historical analysis of the PSH plumes that the PSH on both sides of the boundary between Shell and CORCO are same and likely derived from the CORCO tanks located adjacent to the boundary. Furthermore, this analysis appears to indicate that the product found at the downgradient (southwest corner) of the Shell property originated from the CORCO site.

The fingerprint analysis of samples taken from the discharge point, manhole and Geoprobe locations indicate some variability between the samples. The analysis indicated the manhole sample is a slightly biodegraded form of kerosene but has picked up some heavier non-kerosene product. The product detected in the Geoprobe locations along Rt 127 is most likely representative of the heavier non-kerosene product that has mixed with the kerosene. The sample from the discharge point contained elements of both the manhole sample and the Geoprobe samples, indicating the potential mixing of the PSH plumes as they approach the discharge point.

Based on the fingerprint analysis and conclusions by the independent scientist who conducted the evaluation, it appears that while the sample from Shell MW-101 is consistent with the PSH plume present along the border between Shell and GORCO, it has picked an additional component comprised of kerosene. Kerosene has also been observed in adjacent sample locations, particularly the manhole. Since the kerosene has been identified as relatively fresh, it does not appear possible that it is due to a release from the Shell site since it has been inactive since 1982. Similarly, the fingerprint analysis does not indicate that the kerosene is derived from CORCO facility. This suggests an additional source in the general area of the manhole and product discharge area.

4.0 CONCLUSIONS

The following conclusions can be reached based on review and analysis presented above.

1. Since the Shell Terminal was closed in 1982 and the product was removed from the on-site tanks at that time, the Shell site can only be viewed as a potential source of a PSH release prior to 1982. Any PSH plume released during Shell operations must be considered a mature, stable plume.

2. Although not determinative, soil sampling and screening at the Shell site do not suggest a significant release has occurred at the Shell Site. However, the in-ground construction of Tank 1 and possibly Tank 2 make the detection of a previous release from these tanks difficult.

3. Historical analysis of PSH plume thicknesses strongly suggests that the PSH plume on the Shell site originated at adjacent the CORCO site.

4. Fingerprint analysis of product samples from the Shell and CORCO wells indicate that PSH present along the eastern and southern boundaries of the Shell site are derived from sources on the CORCO property. Fingerprinting of samples from MW-101 in the southeastern corner of the Shell property also indicates that this product has mixed with a second source of primarily kerosene in this area.

5. The fingerprinting of product samples taken from the discharge point to Guayanilla Bay, the nearby sewer manhole, and Geoprobe locations along Rt. 127 indicate significant variability in product composition and suggest the mixing of product from several sources in this area.

6. The fingerprint analysis has identified a relatively fresh release of kerosene in the area of the manhole and southwest corner of the Shell facility. Since the Shell terminal has been inoperative since 1982, an additional, as yet unidentified, release appears to be present in this general area.

7. The fingerprint analysis of samples taken from the discharge point suggests that the product discharging to Guayanilla Bay is likely comprised in part of product from the PSH plume identified along the southern boundary of the CORCO facility.
8. Fingerprinting and historical PSH plume analyses indicate that this PSH plume originated at the CORCO site.

5.0 RECOMMENDATIONS

The following recommendations are provided based on the data and analyses presented above as well as the above conclusions:

1. Since PSH flows in response to internal gradients in the LNAPL phase, the best way to evaluate PSH flow is to examine gradients in the LNAPL phase itself. To further verify conclusions regarding the movement of PSH between the Shell and CORCO properties, contour maps should be developed that depict the top of the PSH layer throughout both sites prior to the expansion of the CORCO recovery system in 2000.

2. Additional investigations should be conducted in the area of the product discharge to Guayanilla Bay, the storm sewer, and southwest corner of the Shell property to identify and characterize the additional release(s) of product that are apparently present in this area.

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